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NATIONAL BUREAU OF STANDARDS REPORT

9927

Examination of
CADMIUM PLATED FUSE BODY REAR
HOUSING COMPONENTS

To
Harry Diamond Laboratories



U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

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NBS PROJECT

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By

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To

Harry Diamond Laboratories

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U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

U. S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234

Examination of
CADMIUM PLATED FUSE BODY REAR
HOUSING COMPONENTS

Submitted by

Harry Diamond Laboratories
NBS Project 8720641
HDL Project No. 70470

By

W. F. Gerhold
Division 312.01

Reference: (a) HDL Work Order, HDL Project No. 70470.

Material: Three cadmium plated rear housing components fabricated from AISI B1112 resulfurized carbon steel were submitted under Reference (a) for examination. The components are cylinders that have been machine bored at each end leaving a thin section separating the two bores. Failures have been reported in certain lots of these components. It was requested that the cause of failure of the components be determined.

Of the three specimens submitted, one was reportedly fabricated from a leaded AISI B1112 carbon steel and was from a lot in which no failures had been reported. The other two components were specimens that had failed and were reportedly fabricated from a non-leaded AISI B1112 carbon steel. One of these specimens failed in an "out-of-line" test conducted in England and was from a lot in which prior failures had occurred. The third specimen failed in an "out-of-line" test conducted at HDL and was from a lot in which no prior failures had been reported.

Visual Examination: Visual examination of the two specimens that had failed, revealed that in each case, the cylinder walls of the larger of the two bores had fractured. The fractures occurred in the area adjacent to one of the small drilled holes used to line up the detonating mechanism. On one of the specimens, the fracture was complete and a portion of the cylinder wall was missing. The fracture on the other specimen was incomplete and the wall was still intact on one side of the fracture, arrow c in Figure 1.

Each specimen was sectioned through the bore. Examination of the base of the large bore of each of the specimens that had failed revealed that the radius at the junction of the base and the cylinder wall was quite sharp. In addition, tool markings from the machining operations appeared excessively deep. These conditions are shown in Figures 1 and 2.

In contrast there was a slight radius between the base and the cylinder wall on the specimen which had not failed, Figure 3. Tool markings on this specimen were quite shallow compared with those noted on the specimens that had failed.

Sharp radii at fillet areas and deep tool markings act as stress raisers. In areas where these conditions exist, such as in the bore at the junction between the base and the cylinder wall, localized stresses are greatly intensified when a load is applied. Thus the concentrated stress induced at the junction of base and wall at the time of detonation could be greater than the design limits of the part. The result would be failures of the type found.

Chemical Analysis: Chemical analyses were obtained for each of the specimens for conformance to chemical composition of AISI B1112 resulfurized carbon steel. These results compared with that specified in Fed. Std. No. 66c are given below.

Specimen No. (a)	Chemical Composition, Percent				
	C	Mn	P	S	Pb
1	0.12	0.85	0.08	0.22	0.28
2	0.13	0.96	0.09	0.17	0.19
3	0.10	0.96	0.10	0.18	0.19
Fed. std. No. 66c	0.13 max	0.70/1.00	0.07/0.12	0.16/0.23	*

* Pb if specified is generally added in a range of 0.15/0.35 percent.

- (a) No. 1 - leaded B1112 resulfurized carbon steel.
No. 2 - B1112 resulfurized carbon steel -- from test conducted in England.
No. 3 - B1112 resulfurized carbon steel -- from test conducted at HDL.

The composition of all of the specimens was within that specified for AISI B1112 resulfurized carbon steel. All could be considered leaded steels, although the one reported to be a leaded steel contained more lead than the other two.

Hardness: Vickers (10 Kg load) hardness determinations were obtained from samples of the three specimens. These determinations converted to Rockwell B along with corresponding approximate tensile strength values were:

Specimen No. (a)	Hardness, R_B	TS, Ksi
1	78	71
2	85	80
3	88	85

- (a) No. 1 - leaded AISI B1112 resulfurized carbon steel.
No. 2 - AISI B1112 resulfurized carbon steel from test conducted in England.
No. 3 - AISI B1112 resulfurized carbon steel from test conducted at HDL.

The hardness of the two specimens that had failed was higher than that which had not failed. However, the difference is not considered to be of a sufficient magnitude to be considered deleterious.

Metallographic Examination: Sections were cut from each of the specimens for metallographic examination. The results of this examination revealed that in each instance, Figures 4a, b, and c, the materials was in the annealed (soft) condition. The matrix of each was predominantly ferrite with pearlite. Areas containing included material, sulfides, were also noted. Sulfide inclusions are generally found in all steels of this type and are not considered harmful. Lead, in the quantity determined by chemical analysis, would be so finely dispersed as to be undetectable by the usual metallographic methods.

Conclusions: Examination of failed fuse body rear housing components indicated that the failures were caused by a lack of a sufficiently large fillet between the cylinder wall and the base of the large bore. There were indications that deep tool markings at these areas may also have contributed to the failures. These conditions resulted in an increase in stress concentration at the time of detonation which was beyond the design limits for the components.

Chemical analyses of the steel used in the fabrication of each of the components was in conformance with that specified in Fed. Std. No. 66c for AISI B1112 resulfurized carbon steel. However only one specimen was reported to have been fabricated from a leaded steel. All specimens contained lead in sufficient quantities for the steel to be considered a leaded steel.

Metallographic examination of sections cut from each of the specimens did not reveal any condition which could have been a contributory factor toward failure.

It is recommended that machining requirements be specified such that there will be as generous a fillet as possible at the junction of the base of the bore and the cylinder walls and that final machining operations are such that deep tool markings are eliminated.

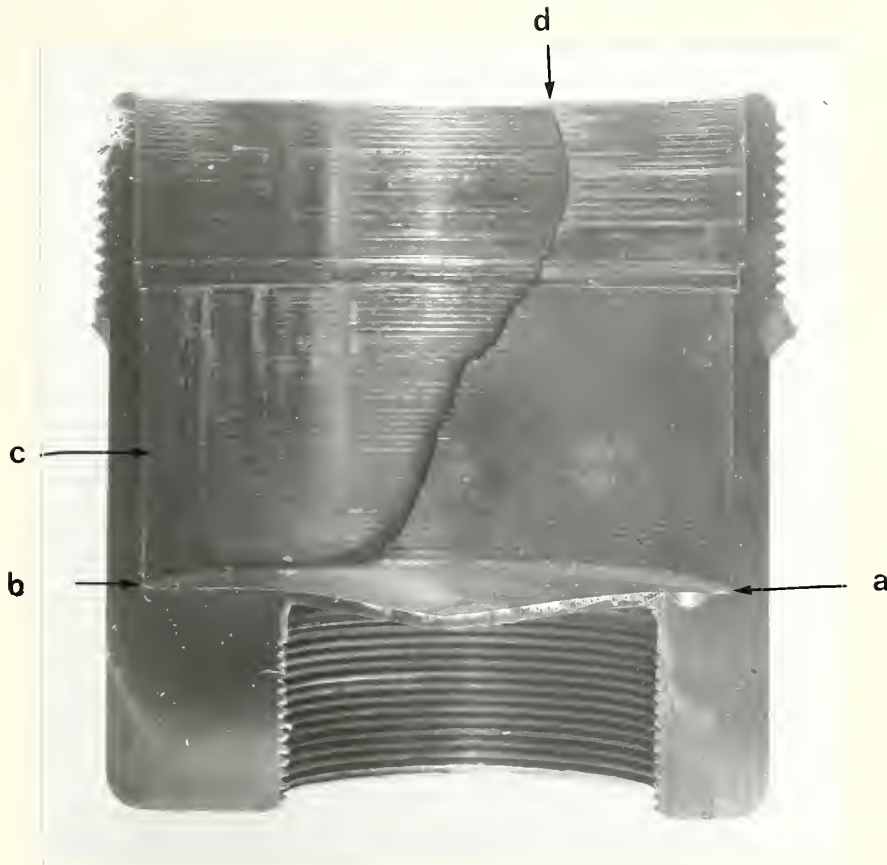


Figure 1. Specimen that had failed in "out-of-line" test conducted at HDL. Fracture was incomplete at one end in area noted by arrow c and complete at other end, arrow d. Arrows a' and b denote areas where there was an abrupt change in contour. Note lack of fillet at these areas as contrasted with that shown in Figure 3. Deep tool markings were also noted on sides of cylinder walls adjacent to these areas.

X 2

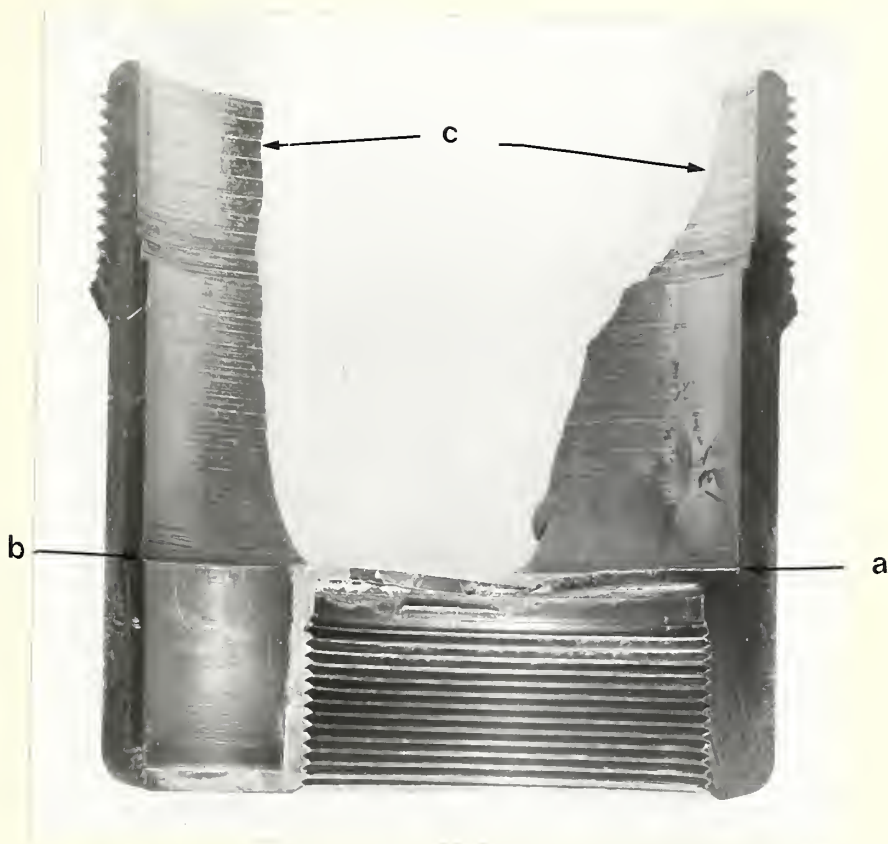


Figure 2. Specimen that had failed in "out-of-line" test conducted in England. Fracture was complete, areas noted by arrows c. Arrows a and b denote similar areas shown in Figure 1. Note lack of fillet at these areas compared with those shown in Figure 3. Deep tool markings were also noted on sides of cylinder walls adjacent to these areas. X 2



Figure 3. Leaded AISI B1112 resulfurized carbon steel specimen from a lot in which no failures had been reported. Note that here there is a slight fillet at the areas (arrows a and b) where there is a change in the contour of the part. Tool markings from the machining operations were shallow compared to those noted on specimens shown in Figures 1 and 2. X 2

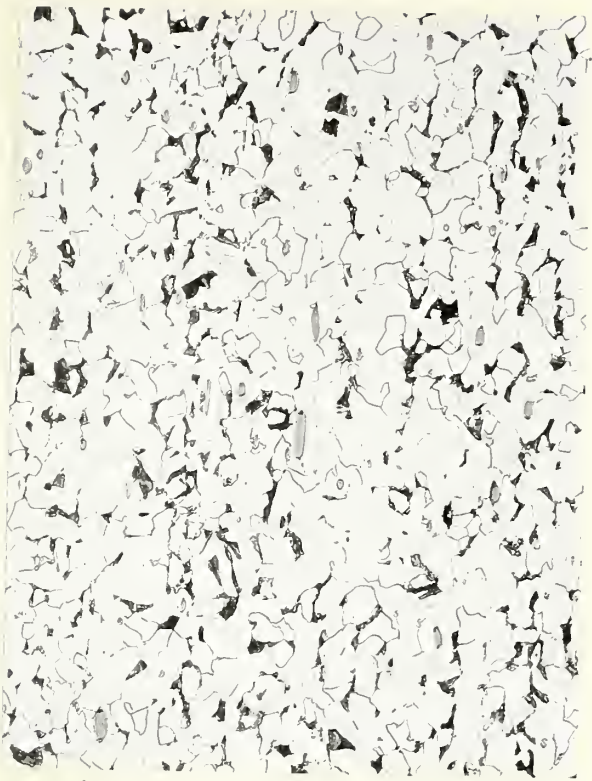
Figure 4.

Photomicrographs of sections cut from each of the 3 specimens submitted. There was no appreciable difference in the microstructures. In each, the matrix is predominantly ferrite (white areas) with pearlite (black areas). Greyish colored stringers are sulfide inclusions. Lead additions, in the quantity determined by chemical analysis, are not detectable by the usual metallographic methods. Etched, 1% Nital. X 100.

- (a) Leaded B1112 resulturized carbon steel.
- (b) B1112 resulturized steel -- from specimen that had failed in out-of-line test conducted in England.
- (c) B1112 resulturized steel -- from specimen that had failed in out-of-line test conducted at HDL.



(a)



(b)



(c)

